Decision support system for comparative radiography

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We introduce a hierarchical decision support system for comparative radiography. This system aims to support the forensic expert in the final decision making by considering multiple sources of information and uncertainty.
Keywords: comparative radiography; decision support; artificial intelligence.

Система підтримки прийняття рішень для порівняльної рентгенографії

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Представлена система підтримки прийняття рішень для порівняльної рентгенографії. Ця система спрямована на підтримку судового експерта на етапі ухвалення остаточного рішення, враховуючи численні джерела інформації та невизначеність.
Ключові слова: порівняльна рентгенографія; підтримка прийняття рішень; штучний інтелект.

Comparative Radiography (CR) [1] allows the identification of individuals based on the comparison of skeletal structures in ante-mortem (AM) and post-mortem (PM) radiographic images. Several skeletal structures have been reported as useful for candidate shortlisting or positive identification using CR, based on their individuality and uniqueness [2]. The most commonly employed skeletal structures in CR are located in the skull (teeth [3], frontal sinuses [4], and the cranial vault [5]), chest, and thoracic areas (clavicles [6] and vertebral features [7]). Outside the traditional areas, a few bones are also used, such as the bones of the hand [8] and the patella [9].

The traditional procedure for identification using CR involves: (1) the study of the biological profile of the PM remains and the filtering of candidates; (2) generation of PM radiographs taken to simulate AM radiographs in orientation and projection; and (3) visual comparison of the radiographs, analyzing consistencies and inconsistencies in the images. However, the acquisition process of a PM radiograph "simulating" the AM one is a complex and error-prone trial-and-error process since small changes in the acquisition parameters result in great changes in the skeletal structures' silhouettes [10]. Furthermore, the process relies entirely on the forensic expert's skills and experience. Consequently, the utility of these methods is reduced because of the time required (2—8 hours per superimposition [11]), the inherent subjectivity, and the errors related to the analyst's fatigue.

CR has undergone a transformative change with the use of 3D imaging techniques and Artificial Intelligence-powered tools, allowing the automatic segmentation of anatomical structures and a shift to 2D-3D and 3D-3D scenarios [12-14]. The introduction of these advancements has not only accelerated the superimposition process but has also enhanced the accuracy of the technique by eliminating subjectivity and standardizing procedures.

Meanwhile the responsibility for final decision making still rests with the forensic expert who performs the visual comparison of the images. In this work we present a hierarchical decision support system (HDSS) to assist the forensic expert in this last stage. The proposed system considers multiple sources of information (matching degree of several radiographies and/or anatomical structures, identification power of each structure, individualizing traits) and uncertainty (image quality, segmentation and/or registration accuracy, remains preservation state).

The underlying technology of the HDSS relies on Computer Vision and Artificial Intelligence to automatically extract relevant similarity metrics from the

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superimposed radiographs, describing properties of the anatomical structures, such as their shape [15]. In addition, the proposed system makes use of Soft Computing techniques such as fuzzy logic to aggregate the information regarding matching degree and uncertainty in the data. Specifically, the framework contemplates four levels of aggregation:

- Level 4 (Criteria): Aggregates the information obtained by different metrics to analyze a particular criterion in an overlay (such as morphological differences between AM and PM information), taking into account the individual reliability of each metric.
- Level 3 (Superimposition): This level aggregates the different criteria evaluated from a superimposition (performed at level 4). This level includes all the information related to a particular overlay, as well as the quality of the analyzed images (resolution, artifacts, etc.).
- Level 2 (Rigid Anatomical Structure): Aggregates the information related to all the superimpositions of a specific anatomical structure (carried out at level 3), as well as the quality of the bone structures involved in the superimposition (conservation state), statistical studies of the discriminatory power of the anatomical structure, the presence of special/infrequent characteristics, and the sum of multiple pieces of evidence from the anatomical structure itself.
- Level 1 (Subject): Finally, level 1 aggregates information from all the anatomical structures available for a determined individual. The output of this level is a global degree of support of a CR identification to assist the decision making process, i.e., a value between zero and one.

The proposed HDSS framework has been validated on preliminary data from PM Computed Tomography (CT). Specifically a sample of 50 individuals (25 male, 25 female) in the age range from 20 to 60, obtained from the New Mexico Decedent Image Database (NMDID) [16]. PM CTs were manually segmented to extract three anatomical structures: paranasal sinuses, maxillary sinuses, and clavicles. From these segmentations three different digitally reconstructed radiographs (DRRs) were generated simulating different AM acquisition protocols per structure. Then, the automatic CR method proposed in [13] was used to generate the superimpositions, resulting in a total number of 22500 NxN comparisons that are then processed by the HDSS.

The resulting scores obtained for each comparison reported by the HDSS are finally used to rank the AM candidates based on their chance to be the actual PM individual. The obtained ranking results are highly promising, as the proposed framework achieved a perfect accuracy (candidates are always ranked in first position) in aggregating data from different sources: multiple AM data, and various anatomical structures with high discriminative power.

Future works will focus on validating the HDSS system for CR using real AM data obtained in different temporal moments and considering other anatomical structures, as well as studying its potential in different conditions of data availability.

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The state of the human psyche in accordance with Article 5 (1(a)) of the human regulation of the European Union on Artificial Intelligence

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The legal course of the European Union has been established to ban AI systems that use subliminal techniques. The concept of "subliminal methods", "beyond the limits of human consciousness" and "material distortion" in the context of damage to the psyche is explained through the assessment of the behavior of a person who has suffered or may potentially suffer psychological damage. The need to expand the scope of banning the use of AI systems is emphasized.

Keywords: prohibition of AI systems, consciousness, subliminal techniques, psychological harm assessment, biometric data processing, biometric psychography.

Стан психіки людини відповідно до статті 5 (1 (а)) регулювання Європейського Союзу про штучний інтелект

Дар'я Булгакова

Установлено правовий курс Європейського Союзу на заборону систем AI, які використовують методи впливу на підсвідоме. Пояснено поняття «підсвідомі методи», «поза межами свідомості людини» та «матеріальне спотворення» в контексті шкоди психіці через оцінку поведінки особи, якій завдана або потенційно може буде завдана психологічна шкода. Підкреслено необхідність розширення сфери заборони застосування систем AI.

Ключові слова: заборона систем штучного інтелекту; свідомість; методи впливу на підсвідомість; визначення психологічної шкоди; обробка біометричних даних; біометрична психографія.

The legislative course of the Artificial Intelligence (AI) Act [4] of the European Union is 'a good moment to take stock of what it can do and what as individuals and as a society we want it to do' [1]. Margrethe Vestager, Executive Vice-President for A Europe Fit for the Digital Age and Competition in the European Commission, cautioned that the 'proposed legal framework does not look at AI technology itself. Instead, it looks at how AI is used and what for' [14]. Although the AI Act defines the legislative concept for an AI system, it fails to clarify what is prohibited for use and how the psychological harm shall be assessed as caused or is likely to be caused.

According to AI Act Article 5 para 1 point (a), 'the placing on the market, putting into service or use of an AI system that deploys subliminal techniques beyond a person's consciousness in order to materially distort a person's behaviour in a manner that causes

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